Pain assessment and mitigation in cattle

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Kansas State University
Part 1: Physiology, measurement and implications of pain
What is Pain?

“An aversive feeling or sensation associated with actual or potential tissue damage Resulting in; physiological, neuroendocrine, and behavioral changes that indicate a “stress” response”
Nociception

1. Tissue Damage
   → Releases bradykinin that releases substance P and prostaglandin

2. Transduction
   → Conversion to electrical energy

3. Transmission
   → A-fibers: sharp, distinct sensations
   → C-fibers: Poorly localized
   → Ascends via spinothalamic tracts

4. Perception
   → Location and intensity of pain

5. Modulation
   → Endogenous analgesia

The neuro-endocrine response to **STRESS**

- Hypothalamus
- Anterior pituitary
- Adrenal cortex
- Corticosteroids
- A.C.T.H.
- Opioid peptides
- Sympathetic nervous system
- Adrenaline, Noradrenaline
Pain challenges in cattle production systems

1. Pain associated with elective procedures:
   - Dehorning (at least 4 million calves/year) and castration (at least 8 million calves/year)
   - Pain has an acute incisional component and chronic inflammatory component
   - Responsive to pre-emptive analgesia
   - 1 in 5 veterinarians use pre-emptive analgesia

Implications: Societal animal welfare concerns; weight loss; BRD is 3 times more likely in bulls castrated on arrival at a feedlot than steers
Percent of respondents (n=189) who use/perform/administer the following at the time of castration

- Analgesics: 21%
- Local Anesthetic: 22%
- Disinfect Scrotum: 22%
- Gloves: 35%
- Tetanus Toxoid: 52%
- Antimicrobials: 54%
- Disinfect Equip: 85%
- Vaccinate: 89%
- Dehorn: 92%

Only 1 in 5 U.S. veterinarians use analgesia at castration
Pain challenges in cattle production systems

2. Pain associated with livestock management and production diseases:

→ Lameness affects 1 million dairy cows in the U.S.
→ Pain hypersensitivity manifests as hyperalgesia (exaggerated responses to painful stimuli) and allodynia (pain resulting from normally innocuous stimuli) → **Refractory to the effects of NSAIDs**
→ Hyperalgesia persists for at least 28 days after causal lesion has resolved (Wray, 1998)

**Implications:** Societal animal welfare concerns; lost production, reproductive failure, mastitis, culling
ACUTE PAIN PROCESSING: NOCICEPTION

1. INFLAMMATION
   Damaged cells release sensitizing chemicals.

2. CONDUCTION
   Passage of action potentials along neurons. Na+ and K+ serum levels may affect pain threshold.

3. TRANSMISSION
   Synaptic transfer and modulation of input from one neuron to the next using chemical messengers (neurotransmitters).

4. MODULATION
   Antinociception
   Neurons originating in brainstem descend to spinal cord and release chemical messengers that inhibit transmission of painful stimuli.

5. PERCEPTION
   Recognition and reaction in the brain. Complex interactions involve thalamus (master switchboard), the sensory cortex, limbic system, and reticular activating system.

CHRONIC PAIN PATHOLOGY

MENTAL OVERLOAD
   Possible neurochemical link between pain and memory. High incidence of depression, anxiety. Suffering increases perceived pain.

LOSS OF NOCICEPTIVE CONTROL
   Normally innocuous stimuli become painful. Once activated, any movement/deformity of tissues becomes painful.

SENSITIZATION
   Repeated pain signals produce changes in the nervous system called WINDUP. Pain becomes more painful.

DAMAGED NERVE
   Damaged sensory nerves may send constant pain signals like an alarm bell that won’t shut off.

NEUROGENIC INFLAMMATION
   Increased prostanoid production at site of pain produces allodynia and hyperalgesia and generates spontaneous pain.
Relevant Research will address stakeholder concerns

- **Consumers Concerns:**
  - Do animals suffer when subjected to routine husbandry/management procedures?
  - How can this suffering be alleviated?

- **Producer Concerns:**
  - Will I be forced to adopt interventions often without scientific/economic justification to be able to sell/export my product?
  - Are there any economic benefits to providing pain relief?
How do we provide effective analgesia in cattle?

- **Mitigate acute pain**
  - Local anesthesia (e.g., lidocaine); general anesthesia?; sedative-analgesia? (e.g., xylazine-ketamine)

- **Ameliorate chronic pain**
  - Control inflammation (e.g., NSAIDs)
  - Control neuropathic pain (e.g., GABA-agonists (gabapentin), NMDA receptor antagonists (e.g., Ketamine))

- **Effective pain relief requires multimodal analgesia**
  - Attack pain at different levels/receptors
Multimodal Analgesia Attacks Different Points Along the Pain Pathway

- **Ascending Input**
- **Spinothalamic Tract**
- **Dorsal root Ganglion**
- **Peripheral nerve**
- **Peripheral Nociceptors**

**Descending Modulation**
- Opioids
- \( \alpha_2 \)-Agonists
- Centrally acting analgesics
- Anti-inflammatory agents (COX-2 specific inhibitors, nonspecific NSAIDs)

**Dorsal Horn**
- Local anesthetics
- Opioids
- \( \alpha_2 \)-Agonists
- Anti-inflammatory agents (COX-2 specific inhibitors, nonspecific NSAIDs)

**Trauma**
- Local anesthetics
- Opioids
- Anti-inflammatory agents (COX-2 specific inhibitors, nonspecific NSAIDs)

Source: Adapted from Gottschalk A et al. Am Fam Physician. 2001;63:1979-84

http://www.physweekly.com/picts/specialxxi03/chart-b.jpg
Why is managing pain in cattle a challenge?

1. Pain recognition is difficult in stoic species
2. No analgesic compounds are specifically approved for analgesic use in cattle in the U.S.
3. Analgesic use requires ELDU under AMDUCA
4. Time delay between drug administration and onset of activity (e.g. local anesthesia)
5. Inconvenient routes of drug administration (IV)
6. Short drug elimination half-lives necessitate frequent drug administration
7. Cost of drugs and meat/milk withhold periods
Why do we not have any drugs approved for analgesia in food animals in the USA?

VI. LABELING

2. Pain

“We (FDA) recommend that this indication be based on the control of clinical signs of pain associated with a disease. We encourage the use of validated methods of pain assessment in the target species”.

FDA Guideline No. 123
DEVELOPMENT OF TARGET ANIMAL SAFETY AND EFFECTIVENESS DATA TO SUPPORT APPROVAL OF NSAIDS FOR USE IN ANIMALS
2. Identifying “validated methods of pain assessment” in cattle

- Behavior
- Plasma Cortisol Determination
- Plasma Substance P Determination
- Accelerometers
- Thermography
- Chute Exit Speed
- Heart Rate Determination
- Electrodermal Activity
- Pressure mats
- EEG
# Universal Pain Assessment Tool

This pain assessment tool is intended to help patient care providers assess pain according to individual patient needs. Explain and use 0-10 Scale for patient self-assessment. Use the faces or behavioral observations to interpret expressed pain when patient cannot communicate his/her pain intensity.

<table>
<thead>
<tr>
<th>Value</th>
<th>Verbal Descriptor Scale</th>
<th>WONG-BAKER FACIAL GRIMACE SCALE</th>
<th>ACTIVITY TOLERANCE SCALE</th>
<th>SPANISH</th>
<th>TAGALOG</th>
<th>CHINESE</th>
<th>KOREAN</th>
<th>PERSIAN (FARSI)</th>
<th>VIETNAMESE</th>
<th>JAPANESE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NO PAIN</td>
<td>Alert Smiling</td>
<td>NO PAIN</td>
<td>NADA DE DOLOR</td>
<td>Walang Sakit</td>
<td>不痛</td>
<td>동통 없음</td>
<td>بدون رد</td>
<td>Không Đau</td>
<td>痛みがない</td>
</tr>
<tr>
<td>1</td>
<td>MILD PAIN</td>
<td>No humor serious flat</td>
<td>CAN BE IGNORED</td>
<td>UNPOQUITO DE DOLOR</td>
<td>Konting Sakit</td>
<td>輕微</td>
<td>악한 통증</td>
<td>떨림이 약한</td>
<td>Dau Nhợ</td>
<td>少し痛み</td>
</tr>
<tr>
<td>2</td>
<td>MODERATE PAIN</td>
<td>Furrowed brow pursed lips breath holding</td>
<td>INTERFERES WITH TASKS</td>
<td>UN DOLOR LEVE</td>
<td>Katamiamang Sakit</td>
<td>中度</td>
<td>보통 통증</td>
<td>드드 뚜름</td>
<td>Dau Vĩa Phát</td>
<td>いくらか痛い</td>
</tr>
<tr>
<td>3</td>
<td>MODERATE PAIN</td>
<td>Wrinkled nose raised upper lips rapid breathing</td>
<td>INTERFERES WITH CONCENTRATION</td>
<td>DOLOR FUERTE</td>
<td>Matinding Sakit</td>
<td>厳重</td>
<td>심한 통증</td>
<td>드드 시립</td>
<td>Dau Nồng</td>
<td>かなり痛い</td>
</tr>
<tr>
<td>4</td>
<td>SEVERE PAIN</td>
<td>Slow blink open mouth</td>
<td>INTERFERES WITH BASIC NEEDS</td>
<td>DOLOR DEMASIADO FUERTE</td>
<td>Pinaka-Matinding Sakit</td>
<td>非常嚴重</td>
<td>아주 심한 통증</td>
<td>뜨거운 통증</td>
<td>Dau Thớt Nồng</td>
<td>ひどく痛い</td>
</tr>
<tr>
<td>5</td>
<td>WORST PAIN POSSIBLE</td>
<td>Eyes closed moaning crying</td>
<td>BEDREST REQUIRED</td>
<td>UN DOLOR INSOPORTABLE</td>
<td>Pinaka-Malang Sakit</td>
<td>最嚴重</td>
<td>최악의 통증</td>
<td>뜨거운 통증</td>
<td>Dau Đón Tổn Còng</td>
<td>ものすごく痛い</td>
</tr>
</tbody>
</table>
**UNIVERSAL PAIN ASSESSMENT TOOL**

This pain assessment tool is intended to help patient care providers assess pain according to individual patient needs. Explain and use 0-10 Scale for patient self-assessment. Use the faces or behavioral observations to interpret expressed pain when patient cannot communicate his/her pain intensity.

<table>
<thead>
<tr>
<th>Verbal Descriptor Scale</th>
<th>NO PAIN</th>
<th>MILD PAIN</th>
<th>MODERATE PAIN</th>
<th>MODERATE PAIN</th>
<th>SEVERE PAIN</th>
<th>WORST PAIN POSSIBLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
<td>flat</td>
<td>breath holding</td>
<td>INTERFERS WITH TASKS</td>
<td>INTERFERS WITH CONCENTRATION</td>
<td>INTERFERS WITH BASIC NEEDS</td>
<td>crying</td>
</tr>
</tbody>
</table>

**ACTIVITY TOLERANCE SCALE**

<table>
<thead>
<tr>
<th>SPANISH</th>
<th>NADA DE DOLOR</th>
<th>UNPOQUITO DE DOLOR</th>
<th>UN DOLOR LEVE</th>
<th>DOLOR FUERTE</th>
<th>DOLOR DEMASIADO FUERTE</th>
<th>UN DOLOR INSOPORTABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAGALOG</td>
<td>Walang Sakit</td>
<td>Konting Sakit</td>
<td>Katamiamang Sakit</td>
<td>Matinding Sakit</td>
<td>Pinaka-Matinding Sakit</td>
<td>Pinaka-Malalang Sakit</td>
</tr>
<tr>
<td>CHINESE</td>
<td>不痛</td>
<td>輕微</td>
<td>中度</td>
<td>嚴重</td>
<td>非常嚴重</td>
<td>最嚴重</td>
</tr>
<tr>
<td>KOREAN</td>
<td>통증 없음</td>
<td>약한 통증</td>
<td>보통 통증</td>
<td>심한 통증</td>
<td>아주 심한 통증</td>
<td>최악의 통증</td>
</tr>
<tr>
<td>PERSIAN (Farsi)</td>
<td>بدون درد</td>
<td>درد ملایم</td>
<td>درد معتدل</td>
<td>درد شدید</td>
<td>درد بسیار شدید</td>
<td>بدترین درد ممکن</td>
</tr>
<tr>
<td>VIETNAMESE</td>
<td>Không Đau</td>
<td>Đau Nhợ</td>
<td>Đau Vùa Phải</td>
<td>Đau Nồng</td>
<td>Đau Thót Nồng</td>
<td>Đau Đơn Tôn Công</td>
</tr>
<tr>
<td>JAPANESE</td>
<td>痛みがない</td>
<td>少し痛い</td>
<td>いくらか痛い</td>
<td>かなり痛い</td>
<td>ひどく痛い</td>
<td>ものすごく痛い</td>
</tr>
</tbody>
</table>
Behavioral Assessment

- Escape Behaviors
- Stamp feet
- Tail swishing
- Abnormal posture
- Lying
- **Subjective**
Plasma Cortisol Determination

- Ketoprofen, Meloxicam and lidocaine prior to castration have been shown to reduce acute plasma cortisol response in cattle.

- Elevated cortisol response is not pain specific.

![Diagram of the neuro-endocrine response to stress](image)

- C<sub>max</sub>
- AUEC
- T<sub>max</sub>
Serum cortisol concentrations (nmol/L) following sham castration and dehorning (Control) and castration and dehorning.

Time (Minutes)

Cortisol (nmol/L)
## Peak plasma cortisol concentration (Cmax) (nmol/L) with time (Tmax) (minutes) following castration

<table>
<thead>
<tr>
<th>Method</th>
<th>6 days</th>
<th>21 days</th>
<th>42 days</th>
<th>2 – 4 months</th>
<th>5.5 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubber ring</td>
<td>60 (36 min)</td>
<td>45 (48 min)</td>
<td>45 (60 min)</td>
<td>76 (90 min)</td>
<td></td>
</tr>
<tr>
<td>Latex Band</td>
<td></td>
<td></td>
<td></td>
<td>101 (30 – 60 min)</td>
<td></td>
</tr>
<tr>
<td>Burdizzo</td>
<td>80 (24 min)</td>
<td>50 (24 min)</td>
<td>60 (24 min)</td>
<td>64 (30 min)</td>
<td>87 (30 min)</td>
</tr>
<tr>
<td>Surgery (Pull)</td>
<td>105 (24 min)</td>
<td>65 (24 min)</td>
<td>110 (24 min)</td>
<td>68 (30 min)</td>
<td>129 (30 min)</td>
</tr>
<tr>
<td>Surgery (Cut)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

# Duration of plasma Cortisol response (Cortisol concentrations above pre-treatment levels)

<table>
<thead>
<tr>
<th>Method</th>
<th>6 days</th>
<th>21 days</th>
<th>42 days</th>
<th>2 – 4 months</th>
<th>5.5 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubber ring</td>
<td>132 min</td>
<td>96 min</td>
<td>132 min</td>
<td>132 min</td>
<td>180 min</td>
</tr>
<tr>
<td>Latex Band</td>
<td>60 min</td>
<td>60 min</td>
<td>72 min</td>
<td>90 min</td>
<td>90 min</td>
</tr>
<tr>
<td>Burdizzo</td>
<td>132 min</td>
<td>84 min</td>
<td>132 min</td>
<td>180 min</td>
<td></td>
</tr>
<tr>
<td>Surgery (Pull)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>360 – 600 min</td>
</tr>
<tr>
<td>Surgery (Cut)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Difference in mean plasma cortisol concentrations from baseline and associated analgesic drug concentrations following castration with or without 0.1 mg/kg Ketamine and/or 0.05 mg/kg Xylazine

- No Difference
- Cortisol above baseline for longer in X and X+K
- Significant attenuation of cortisol response in X and X+K groups
$R^2 = 0.39$
Mean (pooled SEM) percent reduction in peak plasma cortisol following castration with pre-emptive analgesia. Number in parentheses indicates studies reviewed.
Substance P

- Substance P (SP) is an 11- amino acid prototypic neuropeptide.
- Plasma SP levels are up to 27 fold higher in human patients with soft tissue injury.
- We hypothesized that SP may be a more specific measure of pain following castration than cortisol.

http://courses.washington.edu/conj/sensory/pain.htm
Mean ± SEM cortisol concentration in castrated calves (78.88 ± 10.07 nmol/L) was similar to uncastrated control calves (73.01 ± 10.07 nmol/L) (p=0.64)

Mean Substance P concentration in castrated calves (506.43 ± 38.11 pg/mL) was significantly higher than the control calves (386.42 ± 40.09 pg/mL) (p = 0.042)
Accelerometers

- Measure the position of the leg in 3 planes
- 10 readings/ second
- Lying down activity: No movement for 5 seconds
- Standing
- Walking
- Grazing
Accelerometers

- Accelerometers placed on hind limbs
- Data recorded pre and post castration (n=6 per group).
- Castrated calves spent more time (P < 0.05) standing (79.3%) compared to pre-castration readings (51.2%) or control calves after castration (64.3%).
- Calves spent a lower percentage of the time eating post-castration.

White, Coetzee, Renter, Andresen, 2007. AJVR. In press
Thermography

- Detects thermographic differences associated with changes in cutaneous perfusion
- Pain causes alterations in sympathetic tone
  - Results in changes in superficial vascular blood supply.
  - Gives rise to quantifiable changes in localized body temperature
Acute Pain

Parasympathetic

Electrical signals from neuron

Time

Moderate signal rate results in a blood vessel of intermediate diameter.

Change in signal rate

If the signal rate increases, the blood vessel constricts.

If the signal rate decreases, the blood vessel dilates.

Tonic control regulates physiological parameters in an up-down fashion.
Chute Exit Speeds

- Burrows and Dillon (1997) and Fell et al. (1999) used radar speed cameras to measure the speed of cattle exiting a squeeze chute.
- Cattle with faster exit speeds had lower weight gains, more sickness, and more dark cutting meat.


- Doesn’t work well for acclimated or quiet cattle
Mean chute exit speed (m/s) following butorphanol (0.01 mg/kg)- xylazine (0.05 mg/kg)-ketamine (0.1 mg/kg) administration prior to and at the time of dehorning and castration (n= 20 calves/group)
Heart Rate Determination

- Telemetric analysis of heart rate
- Equine Heart Rate Monitor
- Reading every 15 seconds
- Data recorded to wrist watch for downloading and analysis
- May be elevated due to stress of handling
### Heart Rate (HR) Log

#### Graph 1
- **Date**: 07/12/2008
- **Time**: 6:36:26 AM
- **HR**: 84 bpm

#### Graph 2
- **Date**: 07/17/2008
- **Time**: 6:36:16 AM
- **HR**: 73 bpm

<table>
<thead>
<tr>
<th>Horse</th>
<th>Call</th>
<th>Date</th>
<th>Time</th>
<th>Heart rate average</th>
<th>Heart rate max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>7/12</td>
<td>6:36:26</td>
<td>84 bpm</td>
<td>120 bpm</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>7/17</td>
<td>6:36:16</td>
<td>73 bpm</td>
<td>145 bpm</td>
</tr>
</tbody>
</table>
Electrodermal Activity (Pain Gauge)

- Reportedly measures sympathetic tone in skin through changes in skin electrical conductivity
- Electrodes on nasal planum
- Scale of 1 – 10 where 1 is minimal and 10 is stressful
Mean Electrodermal Activity (EDA) following butorphanol (0.01 mg/kg) - Xylazine (0.05 mg/kg) - Ketamine (0.1 mg/kg) administration prior to and at the time of dehorning and castration (n= 12 calves/group)
Pressure Mats

- Walkway with two sensor mats in series
- Computer software allows real-time recording of all phases of stride
  - the duration of stride,
  - length of stride,
  - force throughout the stride,
  - force distribution, and
  - moment of inertia.
- This allows complete characterization of how much weight is being carried on each foot.
Lameness Scoring

Score 1: Normal

Score 2: Stands with a flat back; arches back when walks

Score 3: Stands and walks with an arched back; short stride

Score 4: Stands & walks with arched back; one limb favored

Score 5: Arched back; limb not bearing weight; slow moving
Contact Pressure by Lameness Score

Mean Contact Pressure (kg/cm²)

Lameness Score

Values range from 0.00 to 9.00.
Electroencephalography (EEG)

- Measurement of electrical activity on the scalp produced in brain

**Effects of Age:** EEG responses in lambs undergoing castration under light halothane anesthesia varied with age.

**Effects of Method:** EEG differences are seen with tonic pain (surgical castration) and phasic pain (non-surgical castration)

**Preemptive Analgesia:** Quantitative EEG analyses are used to quantify anesthetic drug effects.
Wave Patterns

- **Beta**-dominant in alert/anxious patients
- **Alpha**-dominant in relaxation
- **Theta**- Drowsiness or arousal
- **Delta**- High amplitude/slowest waves → Sleep
What do we measure?

- Wave Frequency
- Wave Peak
- Absolute Power: Spectral energy of the frequency bands (Cortisol activity)
- Relative Power: Ratio between absolute power of a given band and the total power across all bands.

→ Standardizes measurements across animals
6 week old calves
6 month old calves
Future Studies

- **Effects of Method:** EEG differences may be seen with tonic pain (surgical castration) and phasic pain (non-surgical castration)

- **Preemptive Analgesia:** Quantitative EEG analyses may be used to quantify anesthetic/analgesic drug effects.
Implications of Dehorning and Castration
Growth and Performance

- Castrating feeder cattle decreased performance.
- Calves surgically castrated had improved ADG relative to calves castrated by banding.
- Local anesthesia with lidocaine had no effect on performance, post-castration behavior or vocalization during castration.


- Not a true correlation with acute pain
- Gain may also be negatively influenced by removal of testosterone source
### Cutter Bulls vs. Steers

#### Table 1. Effect of Gender Status upon Arrival on Calf Performance

<table>
<thead>
<tr>
<th>Item</th>
<th>Steers</th>
<th>Bulls</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Head</td>
<td>967</td>
<td>1,795</td>
</tr>
<tr>
<td>Starting wt, lb</td>
<td>468</td>
<td>464</td>
</tr>
<tr>
<td>60 d wt, lb</td>
<td>599</td>
<td>581</td>
</tr>
<tr>
<td>60 d, ADG</td>
<td>2.23</td>
<td>1.95</td>
</tr>
<tr>
<td>Morbidity, %</td>
<td>18.7</td>
<td>25.1</td>
</tr>
<tr>
<td>Mortality, %</td>
<td>.72</td>
<td>2.28</td>
</tr>
</tbody>
</table>

Dale Blasi, 27 loads of calves received at KSU Beef Stocker Unit

#### Table 6. Estimate Table — Difference Between Steers and Bulls

<table>
<thead>
<tr>
<th>Item</th>
<th>466 lb</th>
<th>522 lb</th>
<th>550 lb</th>
<th>592 lb</th>
<th>660 lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain, lb</td>
<td>28</td>
<td>31</td>
<td>35</td>
<td>21</td>
<td>37</td>
</tr>
<tr>
<td>Sickness - times steer</td>
<td>1.34</td>
<td></td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Death loss - times steer</td>
<td>3.2</td>
<td></td>
<td>2.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dr Frank Brazle, KSU Stocker Day, 2 October 2008
Cost difference between steers and bulls

On a 550 lb calf a $52.18 difference is $9.48 per cwt

Dr Frank Brazle, KSU Stocker Day, 2 October 2008
Effect of stress on antimicrobial resistance?
Norepinephrine activates bacterial gene expression for transfer of antimicrobial resistance elements

- The IncQ plasmids (Mobilizable plasmids) was identified to increase in calves experiencing concurrent dehorning and castration.
- IncQ was the most prominent change when we performed our microarray.
- A significant increase in IncQ was observed at 1 hour and 6 hours followed by slow reduction reaching normal levels by one week.
Ori V of IncQ vs EUB Real Time PCR

Fold Change

Control 0hr  D/C 0hr  Control 1hr  D/C 1hr  Control 6hr  D/C 6hr  Control 1wk  D/C 1wk

0
1
2
3
4
5
0.0277
0.0359
0.2442

D/C = dehorn ed/cast rated
Final Thoughts

Scientists should recognize that, when research findings related to animal welfare are equivocal or remain unsettled, the question of how animals ought to be cared for and treated will then shift to the realms of ethics and social values.

Dr. Stanley Curtis, Feedstuffs Oct. 2007
Which one of these contributes more to Global Warming?

It's not the one that starts a car.

According to the United Nations Food and Agriculture Organization, animal agribusiness contributes to global warming even more than transportation does. Reducing the amount of meat, eggs, and dairy products in your diet is one of the most effective ways to reduce greenhouse gas emissions. Find out more about farm animal welfare, factory farming's environmental impacts, and what you can do to help.
Animal Welfare
Acknowledgements

Dr. Butch KuKanich

Dr. Lucy Bergamasco for the EEG
Dr Dale Blasi and the stocker unit

USDA NRI- 2008-35204-19238